STUDY OF GaAs(Ti) THIN FILMS AS CANDIDATES FOR IB SOLAR CELLS MANUFACTURING

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ABSTRACT

Thin films of GaAs(Ti) have been deposited by sputtering on glass and n_GaAs substrates under different process conditions. Optical characteristics of these samples have been analyzed to study the potential of this material in intermediate Band solar cell manufacturing.

INTRODUCTION

The development of intermediate band (IB) solar cells is nowadays one of the most attracting target in the field of solar cell manufacturing [1-2].
Quantum Dots IB solar cells have been developed in the past years [3], and different materials have been described as potential bulk IB materials: Si doped with Ti [4], Ti-substituted GaAs and GaP [5-7], III-V and II-VI alloys, in which a small amount of V and VI anions are replaced with isovalent N and O [8].
In this work we report the deposition of GaAs (Ti) thin films by sputtering, having relatively low Ti concentration, which could be useful for realizing the Intermediate Band Solar Cell concept.

SPUTTERING PROCESS DESCRIPTION

A set of thin films have been deposited on glass and n_GaAs substrates under different conditions in a RF Sputtering System :ESM100 Edwards & RFS5 Generator-300W. Two different targets have been used in these processes:

- GaAs (99%)-Ti (0.5%), Purity ; 99,999% , Size: 4" Diameter x 0.125" thick from Angstrom Sciences.

- GaAs(n) <100>, having a Si impurity concentration of 7 x 10^{17} cm^{-3}. Size: 4" Diameter x 325 μm.

A first sputtering process was carried out and thin films of GaAs(Ti), ranging from 60nm to 400 nm thick, were grown by sputtering. The process conditions were: 1) Chamber pressure 5 10^{-3} mbar; 2) Ar flux 10 sccm; 3) The R.F. input power 50 W and 100 W. 4) Deposited at room temperature. The sputtering rates were in the range of 550-800 nm h^{-1}.

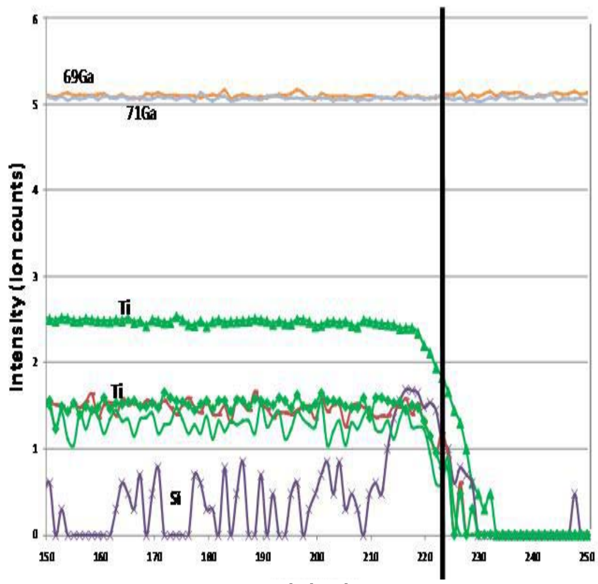

Figure 1 Tof-SIMS of GaAsTi on n-GaAs substrate.

TOF-SIMS (Time-Of-Flight Secondary Ion Mass Spectroscopy) measurements have been carried out in all samples. Ti profiles show good uniformity and constant concentration along the layer deposited, this trend has been observed in all samples analyzed (see Fig. 1).
X-ray diffraction (XRD) measurements have shown that a thermal annealing can help to favoring crystallization of sputtered GaAs thin films [10]. The amorphous network of GaAs films, obtained by sputtering, also decreases by increasing the substrate temperature [11]. For this reason we tried a second sputtering process of GaAs(Ti) on glass substrates. The process conditions were the same that in the first sputtering process except that the R.F. input power: 50 W, 100 W and 200 W, and the deposition temperatures: 20ºC 200ºC and 400ºC, were varied. Table 1 summarizes the process conditions.

Sample	Structure	R.F. power (W)	deposition temperatures (ºC)
PC7A	n_GaAs (ref)	50	20
PC7B	glass-GaAsTi-n_GaAs	50	20
PC Temp1	glass-GaAsTi	200	20
PC Temp2	glass-GaAsTi	200	400
PC Temp3	glass-GaAsTi	100	20
PC Temp4	glass-GaAsTi	100	200

Table 1 Samples and sputtering conditions.

RESULTS OBTAINED

Sub band-gap absorption has been observed in samples obtained in both sputtering processes. Absorptance peaks around 1.3 eV have been detected in the different measurements described below.

Photo reflectance (PR) measurements have been carried out, at the Instituto de Energía Solar- Universidad Politécnica de Madrid, for the different samples analyzed. The absorptance peaks shown (see Fig.2), seem to be the effect of interferences due to the DC and AC signal variations along the measurements, except in the case of sample PC Temp2, where the absorbance peak observed around 1.3 eV can not be explained by these effects analyzing the first and second derivatives of the signal.

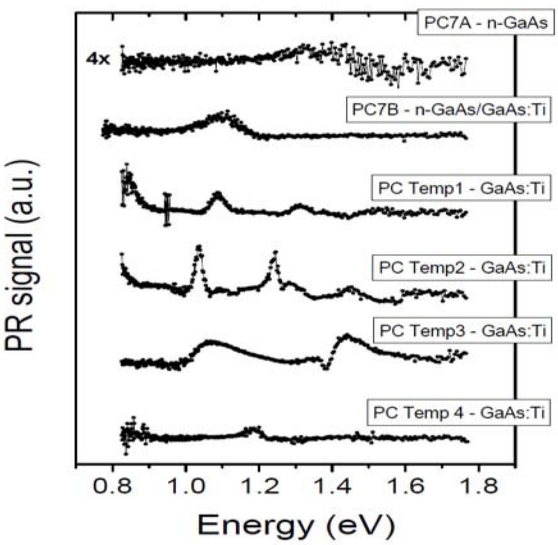

Figure 2 PR measurements.

Furthermore Fourier Transform InfraRed (FT-IR) measurements have also been carried out using a commercial Vertex 70 FT-IR Spectrometer, and an absorbance peak around 1.3 eV, below the crystalline GaAs energy gap, appears again for the sample PC Temp 2 (see Fig. 3).

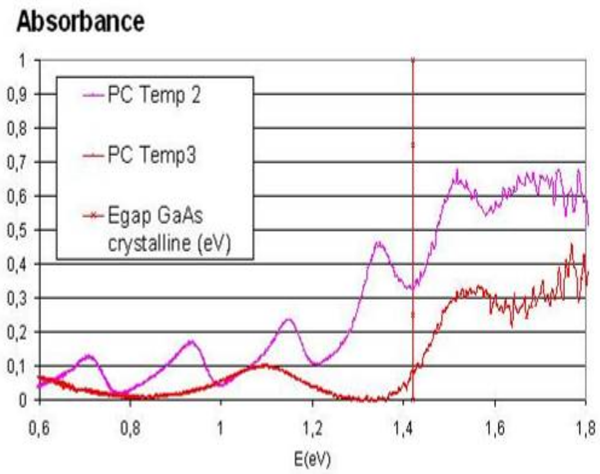

Figure 3 FT-IR measurements.

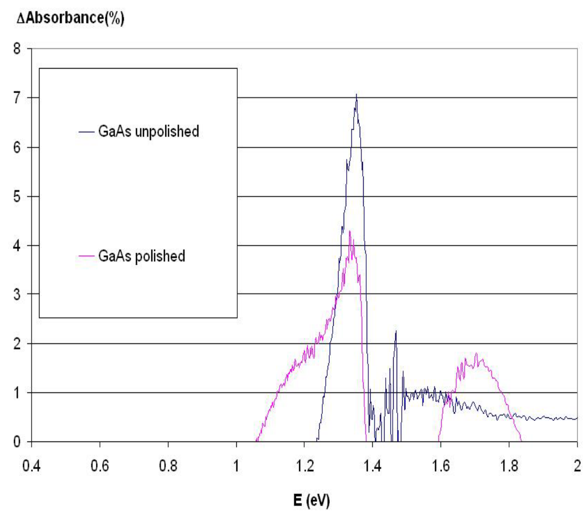

Figure 4 Difference of the absorbance of GaAs(Ti) on n_GaAs samples minus the absorbance of n_GaAs substrates alone.

Finally, absorption measurements have been performed, using an UV-3600 UV-VIS-NIR spectrophotometer, for two samples of GaAs(Ti) thin films deposited in the first sputtering process on n_ GaAs substrates.

We have detected some differences between absorbances of n_GaAs (polished and unpolished) and absorbances of the same substrates having the deposited GaAsTi thin film. Two peaks at 1.33 eV and 1.35 eV can be clearly observed in samples having the GaAs(Ti) layer (see Fig.4). A second absorbance peak at 1.7 eV is also observed in the polished sample having the the GaAs(Ti) layer.

CONCLUSIONS

Thin film of GaAs(Ti) have been deposited by sputtering on glass and n_GaAs substrates. Tof-SiMS measurements confirm that Ti profiles show good uniformity and constant concentration along the layers deposited in all cases.

Thin films of GaAs and GaAs(Ti) have been deposited by sputtering on slides under different process conditions. Optical Absorption is enhanced by Ti in all samples.

Absorbance peaks, around 1.3 eV and 1.7 eV, have been detected in samples of n_GaAs whit thin films of GaAs(Ti) on its surface.

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